Picture This...

Graham Comber
Logging Services Manager, Robertson Geo

Why borehole televiewers have become the tool of choice for geotechnical and mineral investigation.

Robertson Geo is a global market leader in slim-hole logging instrumentation with in-house design and manufacturing facilities and offers a proven logging service worldwide. The expansion and maturation of the market for borehole televiewers is being matched by ongoing developments to keep abreast of demand.

Borehole televiewers provide a continuous, orientated, high-resolution representation of the borehole wall, offering many advantages to geologists and geotechnical engineers. The data provides information about geology, structure, fractures, stress orientation and acts as a template for orientating cores and providing depth control where core recovery is incomplete. In this age of information technology, objective and precise data, captured in situ, is transferred directly from borehole to computer, where it can be stored, processed, analysed and disseminated, literally at the touch of a button.

HOW TELEVIEWERS WORK

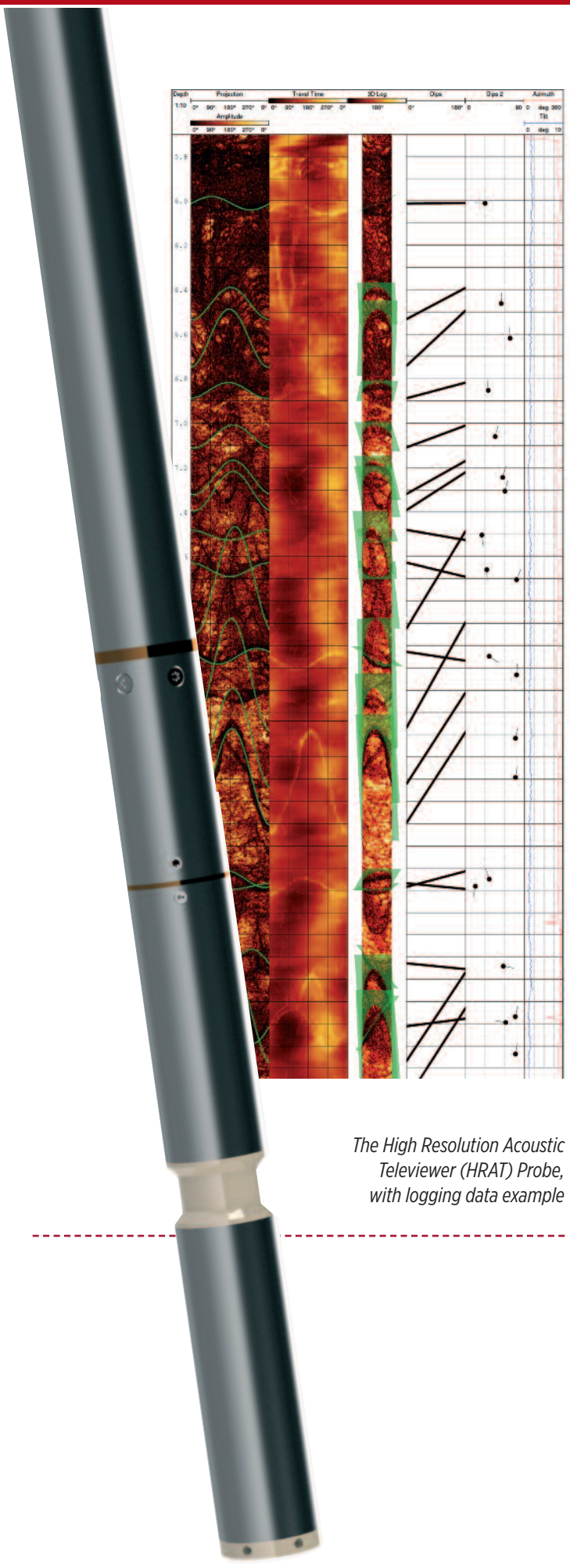
The acoustic televiewer logs the borehole wall in terms of hardness, measuring the amplitude of a high-frequency reflected sonic pulse at very high resolution. It describes the borehole skin rather than the formation beyond. Hard rocks reflect high-amplitude signals and soft rocks and fractures reflect low ones. The individual measurements of reflected amplitude are made continuously by a rotating transducer or, more often in slim tools, a rotating sonic mirror aligned with a stationary transducer. The result is a map of the borehole wall with an individual resolution of about 2mm in ideal conditions. The left edge of the High Resolution Acoustic Televiewer (HRAT) is aligned with magnetic north. Fractures and bedding planes appear as sinusoidal lines where the deepest point on the line is the direction of dip.

On the example to the right, travel times (2nd column from left) for each cycle are mapped in the same way as the amplitudes (left column).

Tool centralisation is important to ensure similar travel time and signal strength in all directions. Resolution is reduced in large boreholes and/or drilling mud where signal dispersal is a problem. Because the acoustic televiewer is sensitive to rock hardness and can measure fracture orientations and apertures (lost in drill core), it has become an important geotechnical tool in both sedimentary and hard-rock formations. A limitation of acoustic tools is that they only function in fluid filled holes.

If data is required from dry boreholes, the High Resolution Optical Televiewer (Hi-OPTV) should be employed. It measures the colour and shade of reflected light. The borehole wall is lit by a ring of diodes on the tool and reflections are directed to a light-sensitive sensor via a conical mirror. Resolution is very high, with pixel sizes down to well below 1mm at HQ borehole diameter.

The optical televiewer provides an orientated photograph of the borehole wall at high resolution and without perspective. The system does not offer a traveltime image, and log quality is dependent on clean borehole fluid if it is run below the water table. In slim holes, optical televiewer images can be of such high quality and value that it is usually worth cleaning the borehole wall and replacing dirty fluid before logging.



The High Resolution Acoustic Televiewer (HRAT) Probe, with logging data example

BATTLE PROVEN TECHNOLOGY

Robertson Geo has been providing borehole televiewer equipment and logging services throughout the world in some of the harshest environments. From offshore wind farms, across the glaciers of Antarctica to underground mines and regular geotechnical applications the televiewer has proved to be a reliable and invaluable tool.

The UK is a world leader in the development of offshore wind farms. Lithological information is key to engineers designing foundations for the massive structures which support the latest generation of turbines. Operating from jack-up platforms or from drill ships, marine resistant technology has allowed televiewers to be included in the armoury of tools available to the geotechnical engineers collecting sub-surface data to feed into the design process. Acoustic televiewers have been deployed offshore on the Dudgeon Wind Farm (UK) and in NW France. Other marine applications include near shore (and onshore) surveys for nuclear build sites at Wylfa and Sizewell B.

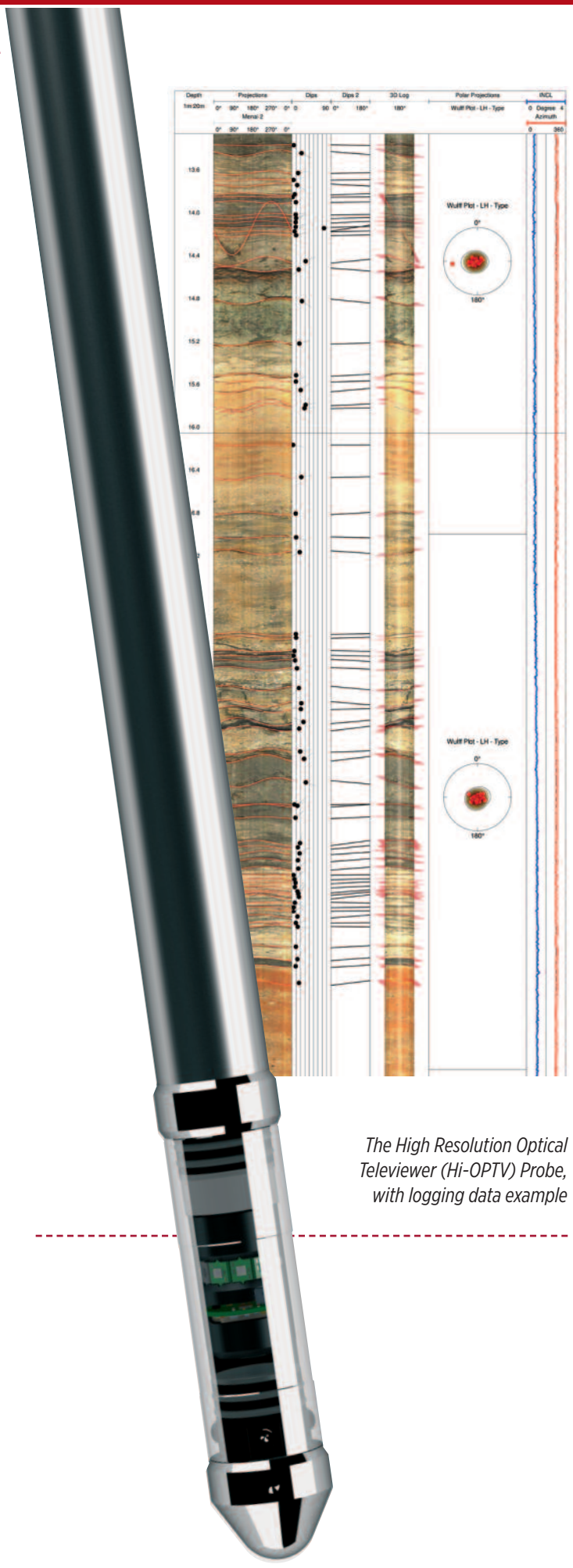
The acoustic televiewer has been deployed extensively in mineral exploration worldwide, quite recently in an underground gold mine development for Dalradian in Northern Ireland where the delineation of the underground fault systems was crucial to the project.

Televiewers have been routinely deployed on many of the UK's largest infrastructure projects including Canary Wharf, HS2, Queensferry Crossing and Lower Thames Crossing in addition to many other linear infrastructure projects. However, the ease of deployment and cost effectiveness of the technology means affordability for even the smallest of projects. Televiewers are deployed extensively worldwide for geotechnical applications such as slope stability.

A seasonal project in Antarctica has seen portable systems with optical televiewers used on glaciers to view ice bands in hot-water drilled boreholes for research purposes.

DRILLING MATTERS

Borehole conditions play a big part in image quality and that is where the drilling personnel should be involved. Rotary drilled boreholes always provide the best images (low rugosity). Televiewers can produce good images in boreholes from 60mm to 300mm with the optimum range being from 75mm to 150mm.



The High Resolution Optical Televiewer (Hi-OPTV) Probe, with logging data example

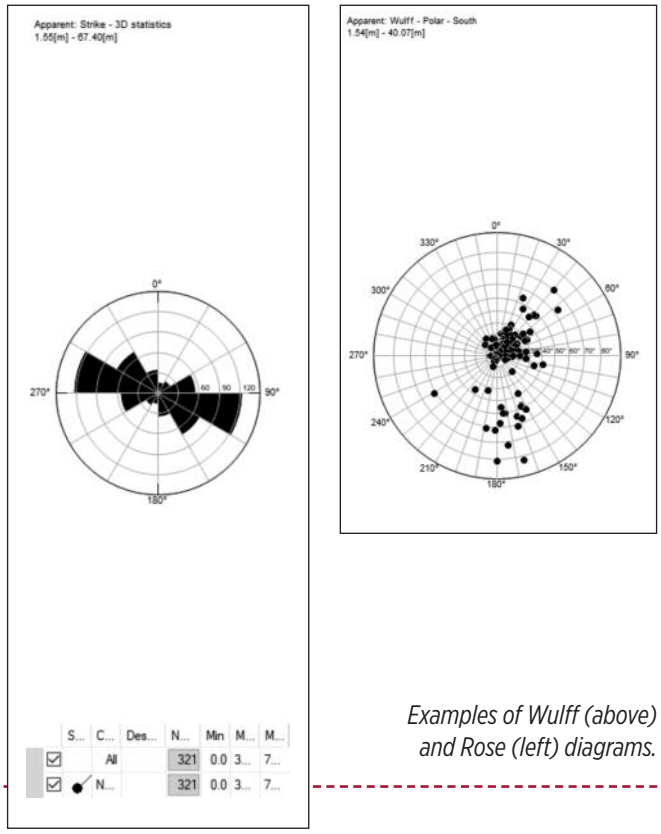
It is important that the borehole be prepared to offer the best conditions for the selected methodology. That might mean, where possible, flushing and cleaning for the optical televiewer. Depending upon the formation a period of time may be required to allow particulates in the fluid time to settle. This time period can be from zero for hard rocks to several days for softer rocks and unconsolidated sedimentary layers. The acoustic televiewer is wholly dependent on a fluid filled borehole but is quite tolerant to mud filled boreholes.

Where borehole stability is an issue the logging is often split into separate runs whereby the drill string is retrieved in stages. To minimise possible loss of data, close liaison with the drillers, geologists and geotechnical personnel is required to confirm where the suspect layers are (e.g. gravel beds). A shooting plan can then be made whereby the drill string can be withdrawn in stages to provide some open borehole while providing protection for the problematic zones. Wherever possible, overlaps should be made between the discreet logs to ensure depth integrity across the borehole.

Using this staged logging method necessitates the televiewer being able to pass through the drill string and drill bit into the open borehole. As the televiewer must be centralised this presents a challenge as the centralisation must be sufficiently weak to allow passage through the smaller diameter drill bit and still maintain centralisation in the larger diameter open borehole. Drill sizes with a relatively large internal diameter compared to borehole diameter (e.g. Geobor S) minimise the centralisation issue.

IMMEDIATE DATA

In addition to the image data being inspected in real time as the logging proceeds, upon completion of the log, the image can be viewed in detail if immediate results are required. It can be enlightening for drillers to view the logs as this provides invaluable feedback for them and the image often confirms the 'feel' they had for the borehole conditions whilst drilling. The fast turnaround of images in the field is now a common requirement for geotechnical personnel and geologists who need to make decisions on depths for further tests, temporary/permanent monitoring installations and potentially amendments to the drilling programme.



Examples of Wulff (above) and Rose (left) diagrams.

PROCESSING

All televiewer data is fully oriented, usually with respect to magnetic north. The tilt and azimuth of the borehole are always recorded to allow correction to true vertical depth and to provide automatic correction for the delineation of features.

Data processing of acoustic and optical images is normally performed in the same way. An empty log is placed over the image and populated by manually picked orientations; sinusoids are fitted over selected features. After picking and classifying by a geologist (fracture, fault, sedimentary bed, vein etc.), the structure log is orientated with respect to horizontal and true north and displayed as a tadpole plot. Feature dips can also be displayed from different view angles and the data can be summarised into various histogram plots and Wulff and Rose diagrams over selected depth ranges and grouped by dip angles or azimuth.

The acoustic televiewer can also produce a breakout log from the travel time data to show washout zones within the borehole. This can be especially useful for calculating grout volumes for boreholes that are to be cased.

'Geobor' is a registered tradename of Atlas Copco
'Q' is a registered trade mark of Boart Longyear International Holdings